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(54) **LUBRICATION SYSTEM FOR A TILTABLE ENGINE**

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F01M 11/06 (2006.01)

(52) **U.S. Cl.**
CPC ***F01M 11/064*** (2013.01); *F01M 2011/0041* (2013.01)

(58) **Field of Classification Search**
CPC F01M 2011/033
USPC .... 123/196 R; 184/6.5
See application file for complete search history.

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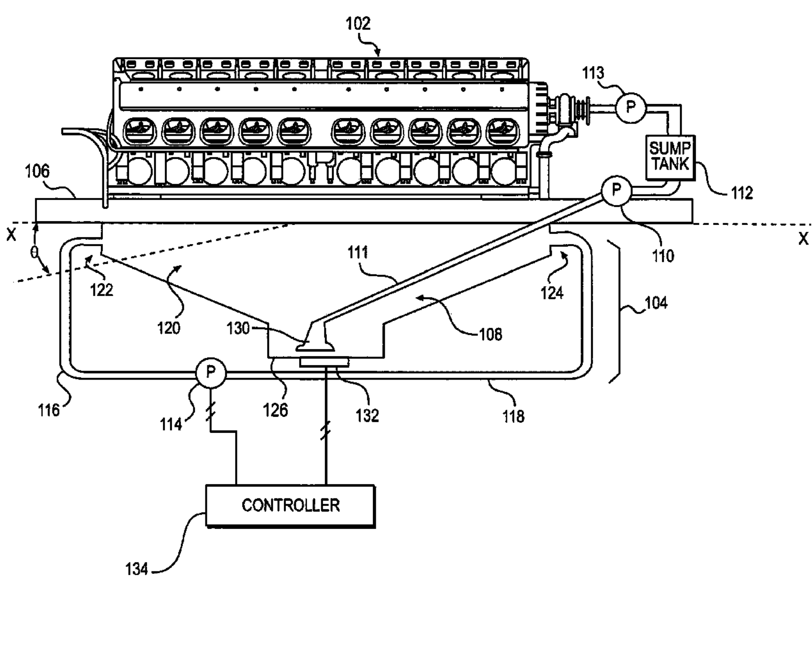
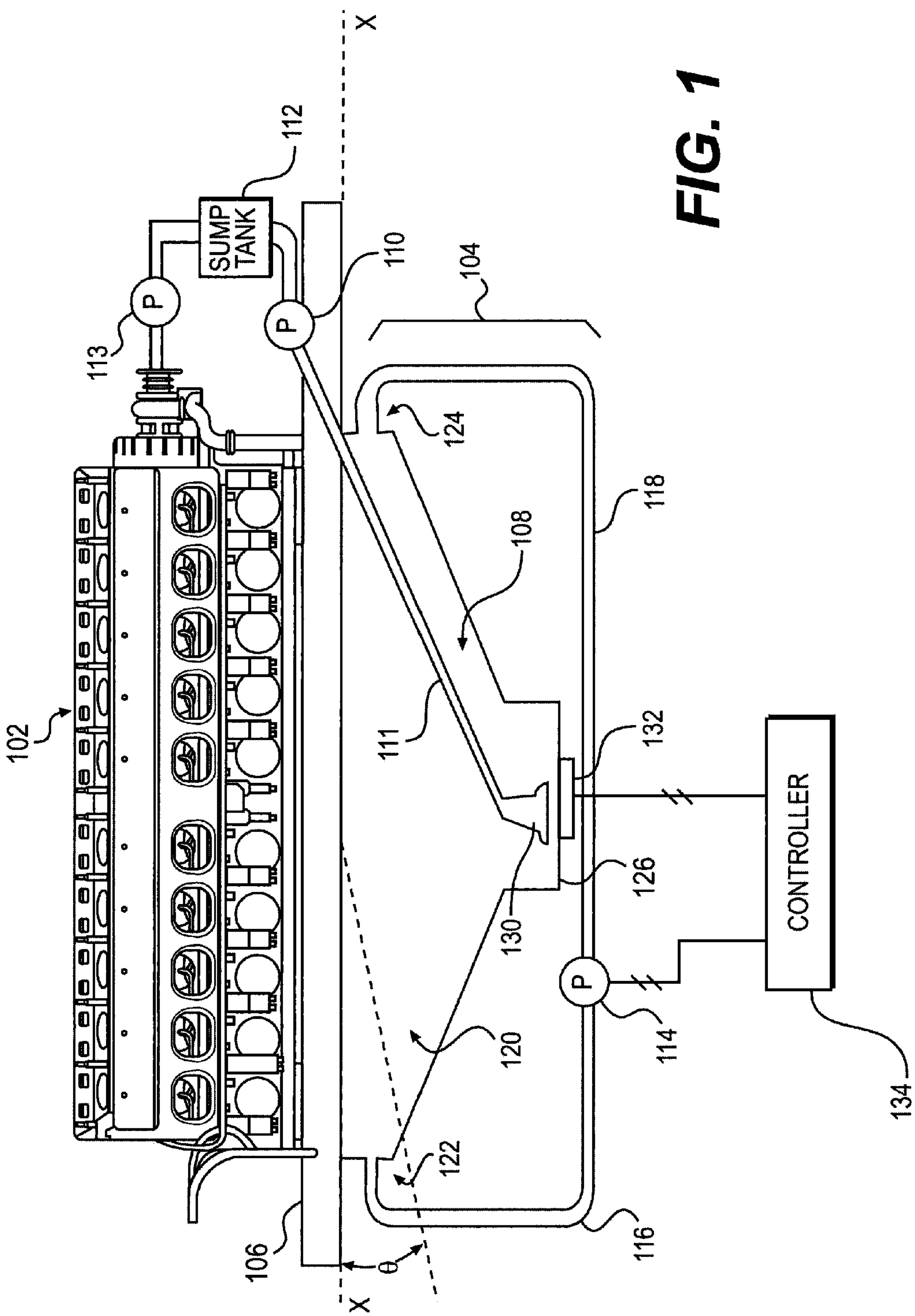
(57) **ABSTRACT**

A lubrication system for an engine is provided. The lubrication system may include an oil pan configured to receive oil from the engine. The oil pan may have a first end, a second end opposite the first end, and a middle portion located between the first and second ends. The lubrication system may also include a suction pump configured to pump oil from the middle portion to the engine, a first conduit fluidly connected to the first end, a second conduit fluidly connected to the second end, and at least one pump fluidly connected to the first and second conduits. The at least one pump may be configured to direct oil from the first end toward the middle portion when the engine is tilted in a first direction and direct oil from the second end toward the middle portion when the engine is tilted in a second direction.

16 Claims, 3 Drawing Sheets




X
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104
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132
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134
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X

FIG. 1

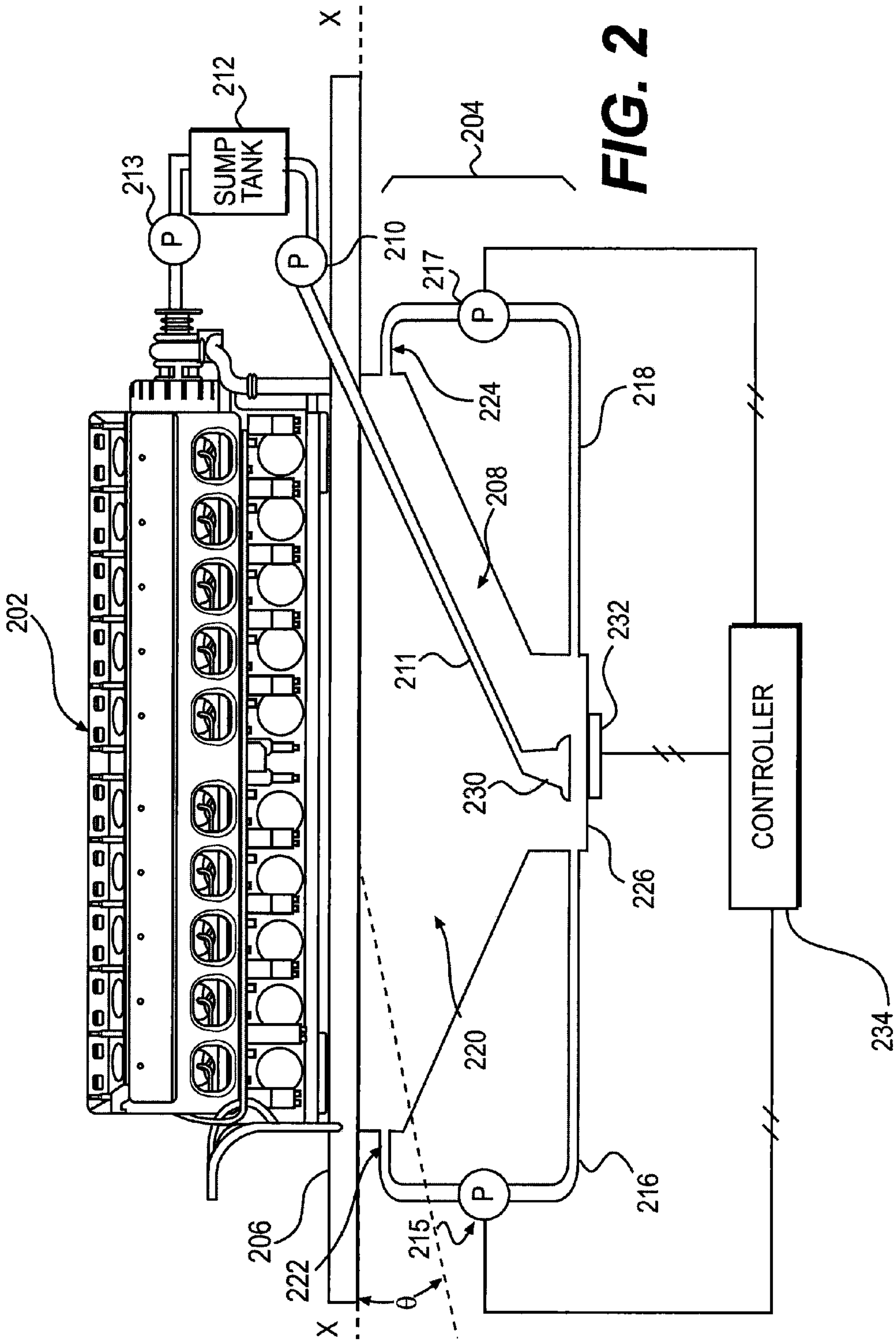
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FIG. 2

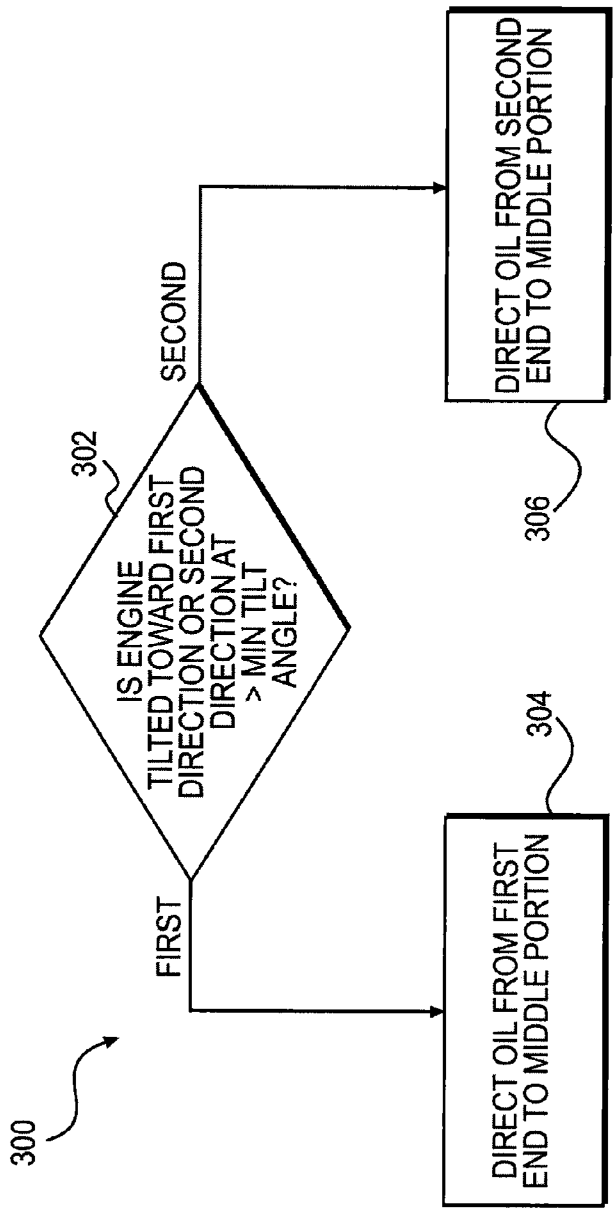
300
IS ENGINE TILTED TOWARD FIRST DIRECTION OR SECOND DIRECTION AT > MIN TILT ANGLE?
302
FIRST
SECOND
DIRECT OIL FROM FIRST END TO MIDDLE PORTION
304
DIRECT OIL FROM SECOND END TO MIDDLE PORTION
306

FIG. 3

LUBRICATION SYSTEM FOR A TILTABLE ENGINE

TECHNICAL FIELD

The present disclosure relates generally to a lubrication system, and more particularly, to a lubrication system for an engine capable of tilting during operation.

BACKGROUND

Traditional lubrication systems circulate oil through an engine to lubricate moving parts, clean the engine, and cool the engine. In a wet sump engine, circulated oil is collected at the base of the engine, where it is pumped back into the engine by an oil pump. In a dry sump engine, circulated oil drains to the base of the engine and is subsequently pumped to an external reservoir by a scavenger pump. The oil is then pumped from the external reservoir back to the engine by a pressure pump.

Oil platforms utilize engine systems to drive machinery and to generate electricity. Severe weather conditions, such as hurricanes and strong winds, may cause the oil platforms to tilt. Both wet sump and dry sump engines may not function properly at tilted angles. When an engine is tilted, oil pools at the lowest point of the engine, which can be away from the associated pump. In such circumstances, either the oil pump (wet sump) or the scavenger pump (dry sump) may not have access to an adequate oil supply to properly lubricate, clean, and cool the engine. This can result in pump starvation and sub-optimal engine performance or even failure.

A system for supplying oil to an engine operating at tilted angles is described in U.S. Pat. No. 3,590,953 ("the '953 patent") of Wellauer that issued on Jul. 6, 1969. The '953 patent describes an engine having an oil pan. An enclosed compartment is formed within the oil pan that is only open to the oil pan by a vent hole. Two oil scavenging bells are located at the front and rear of the oil pan and communicate with an oil scavenging pump. The scavenging pump directs oil from the two scavenging bells into the enclosed compartment at a diffuser oil plate. A suction bell within the enclosed compartment communicates with a circulating pump to deliver oil to the engine.

Although the system of the '953 patent may be capable of operating at tilted angles, it may still be less than optimal. Specifically, because the system of the '953 patent requires an enclosed compartment and other modifications to the oil pan, the '953 system may be complicated and expensive.

The lubrication system and methods of the present disclosure solve one or more of the problems set forth above and/or other problems with existing technologies.

SUMMARY

In one aspect, the disclosure is directed to a lubrication system for an engine. The lubrication system may include an oil pan configured to receive oil from the engine. The oil pan may have a first end, a second end opposite the first end, and a middle portion located between the first and second ends. The lubrication system may also include a suction pump configured to pump oil from the middle portion to the engine, a first conduit fluidly connected to the first end of the oil pan, a second conduit fluidly connected to the second end of the oil pan, and at least one pump fluidly connected to the first and second conduits. The at least one pump may be configured to direct oil from the first end of the oil pan toward the middle portion of the oil pan when the engine is tilted in a first

direction, and direct oil from the second end of the oil pan toward the middle portion of the oil pan when the engine is tilted in a second direction.

In another aspect, the disclosure is directed to a method of lubricating an engine. The method may include directing oil from a middle portion of an oil pan to the engine. The method may also include directing oil from a first end of the oil pan toward an opposing second end of the oil pan when the engine is tilted in a first direction, and directing oil from the second end toward the first end when the engine is tilted in a second direction.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic illustration of an exemplary lubrication system;

FIG. **2** is a diagrammatic illustration of another exemplary lubrication system; and

FIG. **3** is a flowchart illustrating an exemplary disclosed method performed by the lubrication systems of FIG. **1** and FIG. **2**.

DETAILED DESCRIPTION

FIG. **1** illustrates an engine **102** having an exemplary lubrication system **104**. Engine **102** may be mounted to a platform **106**. Platform **106** may be located on an oil platform, marine vessel, or any other suitable platform requiring an engine. Engine **102** is depicted in FIG. **1** and described herein as a diesel-fueled, internal combustion engine. However, it is contemplated that engine **102** may embody any other type of internal combustion engine, such as, for example, a gasoline or gaseous fuel-powered engine. It is contemplated that engine **102** may include any number of combustion chambers and that the combustion chambers may be disposed in an "in-line" configuration, a "V" configuration, or any other conventional configuration.

Lubrication system **104** may be connected to engine **102** and may include an oil pan **108**, a suction pump **110**, a suction conduit **111**, a sump tank **112**, and a pump **113**. Oil pan **108** may be fluidically connected to sump tank **112** via suction pump **110** and suction conduit **111**. Sump tank **112** may be fluidically connected to engine **102** via pump **113**. Lubrication system **104** may also include a reversible pump **114** fluidically connected to a first conduit **116** and a second conduit **118**.

Oil pan **108** may be connected to engine **102** to form a cavity known as a crankcase **120** located below engine **102**. Oil pan **108** may have a first end **122**, an opposing second end **124**, and a middle portion **126**. Oil pan **108** may be sloped from first end **122** to middle portion **126** when engine **102** is substantially level. Oil pan **108** may also be sloped from second end **124** to middle portion **126** when engine **102** is substantially level. Lubricant, for example engine oil, may be provided from oil pan **108** to engine surfaces to reduce metal-on-metal contact and thereby inhibit damage to the surfaces. Oil pan **108** may serve as a sump for collecting and supplying this lubricant. For example, middle portion **126** may be recessed to collect engine oil and may be configured to receive a suction bell **130** of suction conduit **111**. Suction bell **130** may be trumpeted or may have any other known configuration. Engine oil may be pumped directly from middle portion **126** to engine **102** by suction pump **110**. Alternatively, engine oil may be pumped from middle portion **126** to sump tank **112** by suction pump **110**, and subsequently pumped to engine **102** by pump **113**. It should be noted that FIG. **1** depicts only exemplary angles of oil pan **108** and middle portion **126** and that any other suitable sizes and shapes may alternatively be utilized.

Reversible pump **114** may provide directional control of engine oil within oil pan **108** between first end **122** and second end **124** via first conduit **116** and second conduit **118**. First conduit **116** may be configured to receive engine oil at first end **122** of oil pan **108**, and second conduit **118** may be configured to receive oil at second end **124** of oil pan **108**. In one exemplary embodiment, reversible pump **114** may be an electric pump including a DC motor that can be operated in a first rotational direction and in a second, opposite rotational direction. Each rotational direction of the motor may correspond to a flow direction of engine oil through reversible pump **114**. It should be noted however, that any other suitable configuration for reversing flow in reversible pump **114** may alternatively be utilized. Engine oil may be drawn from first end **122** by reversible pump **114** via first conduit **116** and pumped toward second end **124** via second conduit **118**. Similarly, engine oil may be drawn from second end **124** via reversible pump **114** via second conduit **118** and pumped toward first end **122** via first conduit **116**.

Lubrication system **106** may include a tilt sensor **132** configured to detect tilting of engine **102**, and a controller **134** in communication with tilt sensor **132** and reversible pump **114**. Tilt sensor **132** may be, for example, a gyroscope or an accelerometer. However, it should be noted that tilt sensor **132** may be any other suitable mechanism for detecting tilting of engine **102**. Controller **134** may include all the components required to run an application such as, for example, a memory, a secondary storage device, and a processor, such as a central processing unit. One skilled in the art will appreciate that the controller **134** can contain additional or different components. Controller **134** may be dedicated to control of only lubrication system **104** or, alternatively, may readily embody a general engine microprocessor capable of controlling numerous engine functions. Associated with controller **134** may be various other known circuits such as, for example, power supply circuitry, signal conditioning circuitry, and solenoid driver circuitry, among others.

Controller **134** may be configured to adjust a pumping direction of reversible pump **114** based on an output of tilt sensor **132**. That is, when tilt sensor **132** detects that engine **102** is tilted in a first direction (when first end **122** is below a reference plane X and second end **124** is above reference plane X), controller **134** may send a signal to reversible pump **114** to direct oil to middle portion **126** by pumping engine oil from first end **122** toward second end **124** via first conduit **116** and second conduit **118**. Alternatively, when tilt sensor **132** detects that engine **102** is tilted in a second direction (when first end **122** is above reference plane X and second end **124** is below reference plane X), controller **134** may send a signal to reversible pump **114** to direct oil to middle portion **126** by pumping engine oil from second end **124** toward first end **122** via second conduit **118** and first conduit **116**.

Controller **134** may be configured to start operation of reversible pump **114** when tilt sensor **132** detects a minimum tilt angle θ in either the first or second directions. The minimum tilt angle may be less than or equal to a rated operating angle of engine **102**. For example, if engine **102** is rated to operate at a tilt angle of about +/−15 degrees, controller **134** may be configured to start reversible pump **114** when engine **102** is tilted about 12 degrees in the first or second direction. It should be noted, however, that engine **102** may have any other suitable rated operating angle and that controller **134** may utilize any other suitable minimum tilt angle to start reversible pump **114**. Alternatively, controller **134** may start reversible pump **114** when engine **102** is tilted at an angle approximately equal to or greater than the rated operating angle of engine **102**. Controller **134** may also be configured to start reversible pump **114** only when engine **102** is tilted to the minimum tilt angle for at least a minimum amount of time. Controller **134** may be configured to turn off reversible pump **114** when engine **102** is tilted at an angle less than or equal to the minimum tilt angle. In one exemplary embodiment, if engine **102** is rated to operate at a tilt angle of about +/−15 degrees, and the minimum tilt angle is about 12 degrees, controller **134** may be configured to turn off reversible pump **114** when engine **102** is tilted at about 10 degrees to prevent excessive cycling of engine oil. It should be noted however, that any other suitable angle may be utilized by controller **134** to turn off reversible pump **114**.

Controller **134** may be configured to set a pumping displacement of reversible pump **114** based on the tilt of engine **102**. That is, controller **134** may increase the displacement of reversible pump **114** as the tilt of engine **102** increases. As the tilt of engine **102** increases, more engine oil may pool at either first end **122** or second end **124**. As more engine oil pools at first end **122** or second end **124**, less engine oil is available to circulate through engine **102**. To counter this effect, controller **134** may increase the displacement of reversible pump **114** as the tilt of engine **102** increases. Alternatively, to promote fuel efficiency, controller **134** may decrease the displacement of reversible pump **114** when the tilt of engine **102** decreases.

FIG. **2** illustrates an alternative engine **202** having an exemplary lubrication system **204**. Engine **202** may be mounted to a platform **206**. Engine **202** and platform **206** may be substantially similar to engine **102** and platform **106** described in reference to FIG. **1**. Lubrication system **204** may be connected to engine **202** and may include an oil pan **208**, a suction pump **210**, a suction conduit **211**, a sump tank **212**, and a pump **213**. Oil pan **208** may be fluidically connected to sump tank **212** via suction pump **210** and suction conduit **211**. Sump tank **212** may be fluidically connected to engine **202** via pump **213**. Lubrication system **206** may also include a first pump **215**, a first conduit **216**, a second pump **217**, and a second conduit **218**. Oil pan **208** may be fluidically connected to first pump **215** and second pump **217** via first conduit **216** and second conduit **218** respectively.

Oil pan **208** may be connected to engine **202** to form a cavity known as a crankcase **220** located below engine **202**. Oil pan **208** may have a first end **222**, an opposing second end **224**, and a middle portion **226**. Oil pan **208** may be sloped from first end **222** to middle portion **226** when engine **202** is substantially level. Oil pan **208** may also be sloped from second end **224** to middle portion **226** when engine **202** is substantially level. Lubricant, for example engine oil, may be provided from oil pan **208** to engine surfaces to minimize metal-on-metal contact and thereby inhibit damage to the surfaces. Oil pan **208** may serve as a sump for collecting and supplying this lubricant. For example, middle portion **226** may be recessed to collect engine oil and may be configured to receive a suction bell **230** of suction conduit **211**. Suction pump **210**, suction conduit **211**, sump tank **212**, pump **213**, and suction bell **230** may be substantially similar to suction pump **110**, suction conduit **111**, sump tank **112**, pump **113**, and suction bell **130**. It should be noted that FIG. **2** depicts only exemplary angles of oil pan **208** and middle portion **226** and that any other suitable sizes and shapes may alternatively be utilized.

First pump **215** and second pump **217** may provide directional control of engine oil within oil pan **208**. Oil pan **208** may be fluidically connected at middle portion **226** to a first conduit **216** and a second conduit **218**. First conduit **216** may be fluidly connected to first pump **215** and may be configured to receive engine oil at first end **222** of oil pan **208**. Engine oil may be drawn from first end **222** by first pump **215** via first conduit **216** and pumped toward middle portion **226**. Similarly, second conduit **218** may be fluidly connected to second pump **217** and may be configured to receive engine oil at second end **224** of oil pan **208**. Engine oil may be drawn from second end **224** by second pump **217** via second conduit **218** and pumped toward middle portion **226**.

Lubrication system **204** may include a tilt sensor **232**, and may also include a controller **234**. Tilt sensor **232** and controller **234** may be substantially similar to tilt sensor **132** and controller **134** described in FIG. **1** except that controller **234** may be in communication with tilt sensor **232**, first pump **215**, and second pump **217**.

Controller **234** may be configured to selectively determine which of first pump **215** or second pump **217** to operate based on an output of tilt sensor **232**. That is, when tilt sensor **232** detects that engine **202** is tilted in a first direction (when first end **222** is below reference plane X and second end **224** is above reference plane X), controller **234** may send a signal to first pump **215** to direct engine oil from first end **222** toward middle portion **226** via first conduit **216**. Alternatively, when tilt sensor **232** detects that engine **202** is tilted in a second direction (when first end **222** is above reference plane X and second end **224** is below reference plane X), controller **234** may send a signal to second pump **217** to direct engine oil from second end **224** to middle portion **226** via second conduit **218**.

Controller **234** may be configured to start operation of first pump **215** when tilt sensor **232** detects a minimum tilt angle θ in the first direction. Similarly, controller **234** may be configured to start operation of second pump **217** when tilt sensor **232** detects a minimum tilt angle in the second direction. The minimum tilt angle may be less than or equal to a rated operating angle of engine **202**. For example, if engine **202** is rated to operate at a tilt angle of about +/−15 degrees, controller **234** may be configured to start either first pump **215** or second pump **217** when tilt sensor **232** detects that engine **202** is tilted about 12 degrees in the first or second directions, respectively. It should be noted, however, that engine **202** may have any other suitable rated operating angle and that controller **234** may utilize any other suitable angle to start first pump **215** or second pump **217**. Alternatively, controller **234** may start first pump **215** or second pump **217** when engine **202** is tilted at an angle approximately equal to or greater than the rated operating angle of engine **202**. Controller **234** may also be configured to start first pump **215** or second pump **217** when engine **202** is tilted to the minimum angle for a minimum amount of time. Controller **234** may be configured to turn off first pump **215** or second pump **217** when engine **202** is tilted at an angle less than or equal to the minimum tilt angle. In one exemplary embodiment, if engine **202** is rated to operate at a tilt angle of about +/−15 degrees, and the minimum tilt angle is about 12 degrees, controller **234** may be configured to turn off first pump **215** or second pump **217** when engine **202** is tilted at about 10 degrees to prevent excessive cycling of engine oil. It should be noted however, that any other suitable angle may be utilized by controller **243** to turn off first pump **215** or second pump **217**.

Controller **234** may be configured to set a pumping displacement of first pump **215** and second pump **217** based on the tilt of engine **202**. That is, controller **234** may increase the displacement of first pump **215** or second pump **217** as the tilt of engine **202** increases. As the tilt of engine **202** increases, more engine oil may pool at either first end **222** or second end **224**. As more engine oil pools at first end **222** or second end **224**, less engine oil is available to circulate through engine **202**. To counter this effect, controller **234** may increase the displacement of first pump **215** and second pump **217** as the tilt of engine **202** increases. Alternatively, to promote fuel efficiency, controller **234** may decrease the displacement of first pump **215** and second pump **217** when the tilt of engine **202** decreases.

FIG. **3** illustrates an exemplary operation of lubrication systems **104** and **204**. FIG. **3** will be discussed in more detail below.

INDUSTRIAL APPLICABILITY

The disclosed lubrication system may be applicable to any tiltable engine, and allow tiltable engines to operate at larger tilt angles. The disclosed lubrication system may also be retrofit onto existing engines not rated to operate at tilted angles to allow these existing systems to now be classified as tiltable. The disclosed lubrication system may help avoid pump starvation in any engine by pumping oil from pooled locations to an associated suction pump. An exemplary method will now be described.

According to flowchart **300** in FIG. **3**, controllers **134**, **234** may determine if engines **102**, **202** are tilted at an angle greater than the minimum tilt angle in either a first or second direction based on an output of tilt sensors **132**, **232** (Control Block **302**). When controllers **134**, **234** determine that engines **102**, **202** are tilted in a first direction (when first ends **122**, **222** are below reference plane X and second ends **124**, **224** are above reference plane X), controllers **134**, **234** may control reversible pump **114** and first pump **215** to direct oil from first ends **122**, **222** toward middle portions **126**, **226** at Control Block **304**. In a first embodiment, controller **134** may direct oil from first end **122** toward middle portion **126** by sending a signal to reversible pump **114** to pump oil from first end **122** toward second end **124**. Oil may then be gravitationally pulled from second end **124** to middle portion **126**. In an alternative embodiment, controller **234** may direct oil from first end **222** toward middle portion **226** by sending a signal to first pump **215** to pump oil from first end **222** toward middle portion **226**.

When controllers **134**, **234** determine that engines **102**, **202** are tilted in the second direction (when first ends **122**, **222** are above reference plane X and second ends **124**, **224** are below reference plane X), controllers **134**, **234** may control reversible pump **114** and second pump **217** to direct oil from second ends **124**, **224** toward middle portions **126**, **226** at Control Block **306**. In a first embodiment, controller **134** may direct oil from second end **124** toward middle portion **126** by sending a signal to reversible pump **114** to pump oil from second end **124** toward first end **122**. Oil may then be gravitationally pulled from first end **122** to middle portion **126**. In an alternative embodiment, controller **234** may direct oil from second end **224** toward middle portion **226** by sending a signal to second pump **217** to pump oil from second end **224** toward middle portion **226**.

The disclosed lubrication systems **104** and **204** may provide a simple and inexpensive mechanism for allowing engines to operate at tilted angles. For example, the disclosed lubrication systems may function without modifications or with only minor modifications to existing oil pans. The disclosed lubrication systems may also prevent unnecessary maintenance costs by preventing engine malfunctions that occur due to pump starvation. The disclosed lubrication systems may also reduce the amount of engine oil necessary to operate engine systems because less engine oil may pool away from an associated suction pump.

It will be apparent to those skilled in the art that various modifications and variations can be made to the disclosed lubrication system without departing from the scope of the disclosure. Other embodiments of the lubrication system will be apparent to those skilled in the art from consideration of the specification and practice of the lubrication system disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope of the disclosure being indicated by the following claims and their equivalents.

What is claimed is:

1. A lubrication system for an engine, comprising:
an oil pan configured to receive oil from the engine, the oil pan having a first end, a second end opposite the first end, and a middle portion located between the first and second ends;
a suction pump configured to pump oil from the middle portion to the engine;
a first conduit fluidly connected to the first end of the oil pan;
a second conduit fluidly connected to the second end of the oil pan;
at least one pump fluidly connected to the first and second conduits and configured to:
direct oil from the first end of the oil pan toward the middle portion when the engine is tilted in a first direction; and
direct oil from the second end of the oil pan toward the middle portion when the engine is tilted in a second direction;
a tilt sensor configured to detect a tilt of the engine; and
a controller in communication with the tilt sensor and the reversible pump, the controller configured to adjust a pumping direction of the reversible pump based on an output of the tilt sensor;
wherein the at least one pump is a reversible pump to:
pump oil from the first end of the oil pan toward the second end of the oil pan when the engine is tilted in the first direction; and
pump oil from the second end of the oil pan toward the first end of the oil pan when the engine is tilted in the second direction.

2. The lubrication system of claim 1, wherein the controller is further configured to increase a displacement of the reversible pump as a tilt angle of the engine increases.

3. The lubrication system of claim 1, wherein the controller is further configured to start the reversible pump when the tilt of the engine is less than or equal to a rated operating angle of the engine.

4. The lubrication system of claim 1, wherein the at least one pump includes a first pump configured to pump oil from the first end toward the middle portion when the engine is tilted in the first direction, and a second pump configured to pump oil from the second end toward the middle portion when the engine is tilted in the second direction.

5. The lubrication system of claim 1, further including a sump tank connecting the suction pump with the engine.

6. The lubrication system of claim 5, further including an additional pump connecting the sump tank and the engine.

7. A method of lubricating an engine, comprising;
directing oil from a middle portion of an oil pan to the engine;
directing oil from a first end of the oil pan toward an opposing second end of the oil pan when the engine is tilted in a first direction; and
directing oil from the second end toward the first end when the engine is tilted in a second direction;
further including detecting a tilt of the engine, wherein directing oil from the first end of the oil pan toward the second end of the oil pan or directing oil from the second end toward the first end occurs when a tilt angle of the engine is greater than a minimum tilt angle;
wherein directing oil from the first or second ends includes increasing a pumping displacement as the tilt angle of the engine increases.

8. The method of claim 7, wherein directing oil from the middle portion of the oil pan to the engine includes pumping oil through a sump tank external to the engine.

9. The method of claim 8, further including pumping oil from the sump tank to the engine through an additional pump.

10. The method of claim 7 wherein the oil directed from the first end toward the second end and the oil directed from the second end toward the first end is gravitationally pulled to the middle portion of the oil pan.

11. An engine system, comprising:
a platform; an engine mounted to the platform;
an oil pan configured to receive oil from the engine, the oil pan having a first end, a second end opposite the first end, and a middle portion located between the first and second ends;
a suction pump configured to pump oil from the middle portion to the engine;
a first conduit fluidly connected to the first end of the oil pan;
a second conduit fluidly connected to the second end of the oil pan;
at least one pump fluidly connected to the first and second conduits;
a tilt sensor configured to detect a tilt of the engine; and
a controller in communication with the tilt sensor and the at least one pump, the controller configured to:
direct oil from the first end of the oil pan toward the middle portion when the engine is tilted in a first direction based on an output of the tilt sensor;
direct oil from the second end of the oil pan toward the middle portion when the engine is tilted in a second direction based on the output of the tilt sensor; and
adjust a pumping direction of the at least one pump based on the output of the tilt sensor.

12. The engine system of claim 11, wherein the at least one pump is a reversible pump, wherein the controller is further configured to: pump oil from the first end of the oil pan toward the second end of the oil pan when the engine is tilted in the first direction; and pump oil from the second end of the oil pan toward the first end of the oil pan when the engine is tilted in the second direction.

13. The engine system of claim 12, wherein the controller is further configured to increase a displacement of the reversible pump as a tilt angle of the engine increases.

14. The engine system of claim 12, wherein the controller is further configured to start the reversible pump when the tilt of the engine is less than or equal to a rated operating angle of the engine.

15. The engine system of claim 11, wherein the at least one pump includes a first pump configured to pump oil from the first end toward the middle portion when the engine is tilted in the first direction, and a second pump configured to pump oil from the second end toward the middle portion when the engine is tilted in the second direction.

16. A lubrication system for an engine, comprising:
an oil pan configured to receive oil from the engine, the oil pan having a first end, a second end opposite the first end, and a middle portion located between the first and second ends;

a suction pump configured to pump oil from the middle portion to the engine;
a first conduit fluidly connected to the first end of the oil pan;
a second conduit fluidly connected to the second end of the oil pan; and
at least one pump fluidly connected to the first and second conduits and configured to:
direct oil from the first end of the oil pan toward the middle portion when the engine is tilted in a first direction; and
direct oil from the second end of the oil pan toward the middle portion when the engine is tilted in a second direction;
wherein the at least one pump is a reversible pump configured to:
pump oil from the first end of the oil pan toward the second end of the oil pan when the engine is tilted in the first direction; and
pump oil from the second end of the oil pan toward the first end of the oil pan when the engine is tilted in the second direction; and
wherein the lubrication system further includes:
a tilt sensor configured to detect a tilt of the engine; and
a controller in communication with the tilt sensor and the reversible pump, the controller configured to adjust a pumping direction of the reversible pump based on an output of the tilt sensor.

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UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO. : 9,157,348 B2
APPLICATION NO. : 13/363131
DATED : October 13, 2015
INVENTOR(S) : Hodges

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In the claims

Column 7, line 36, claim 1, delete "pump to" and insert -- pump configured to --.

Column 8, lines 43-49, claim 12, delete "The engine system of claim 11, wherein the at least one pump is a reversible pump, wherein the controller is further configured to: pump oil from the first end of the oil pan toward the second end of the oil pan when the engine is tilted in the first direction; and pump oil from the second end of the oil pan toward the first end of the oil pan when the engine is tilted in the second direction." and insert -- The engine system of claim 11, wherein the at least one pump is a reversible pump, wherein the controller is further configured to:

pump oil from the first end of the oil pan toward the second end of the oil pan when the engine is tilted in the first direction; and

pump oil from the second end of the oil pan toward the first end of the oil pan when the engine is tilted in the second direction. --.

Signed and Sealed this
Twenty-fifth Day of October, 2016

Michelle K. Lee

Michelle K. Lee
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